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DATA SCIENCE & POSTGRESQL

When it all GOes right

Writing applications with Go for PostgreSQL

When it all GOes right

Pavlo Golub

Senior Consultant/Developer

pavlo.golub@cybertec.at

@PavloGolub

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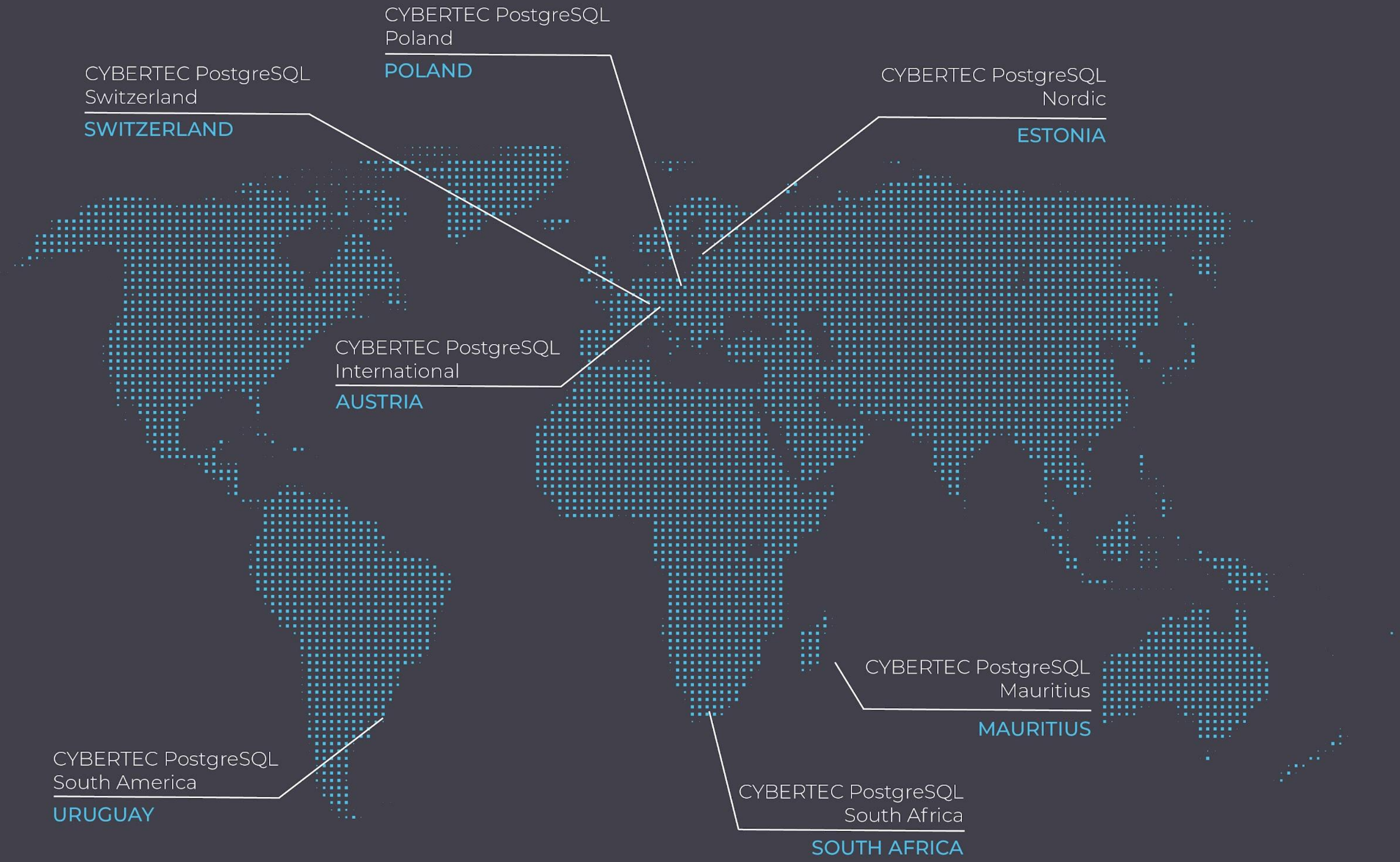
About CYBERTEC

- Inhouse development
- International team of developers
- Specialized in data services
- Owner-managed since 2000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POLAND
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SWITZERLAND
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ESTONIA
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AUSTRIA
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SOUTH AFRICA

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CLIENT SECTORS

- ICT
- University
- Government
- Automotive
- Industry
- Trade
- Finance
- etc.

Klarna.
BMW
hp
amazon
bon prix
Atos
skype™
Lufthansa
WILLHABEN
voestalpine
SPAR
SBB Cargo
hims
PORSCHE
IBM®
NOKIA
ÖBB
Audi
METRO
MAGNA
SIEMENS
Magenta
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DER VERKEHRSVERBUND
ALCATEL

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DATABASE SERVICES

DATA SCIENCE

- Artificial Intelligence
- Machine Learning
- Big Data
- Business Intelligence
- Data Mining
- etc.

POSTGRESQL

- 24/7 Support
- Training
- Consulting
- Performance Tuning
- Clustering
- etc.

POSTGRESQL DATABASE SERVICES

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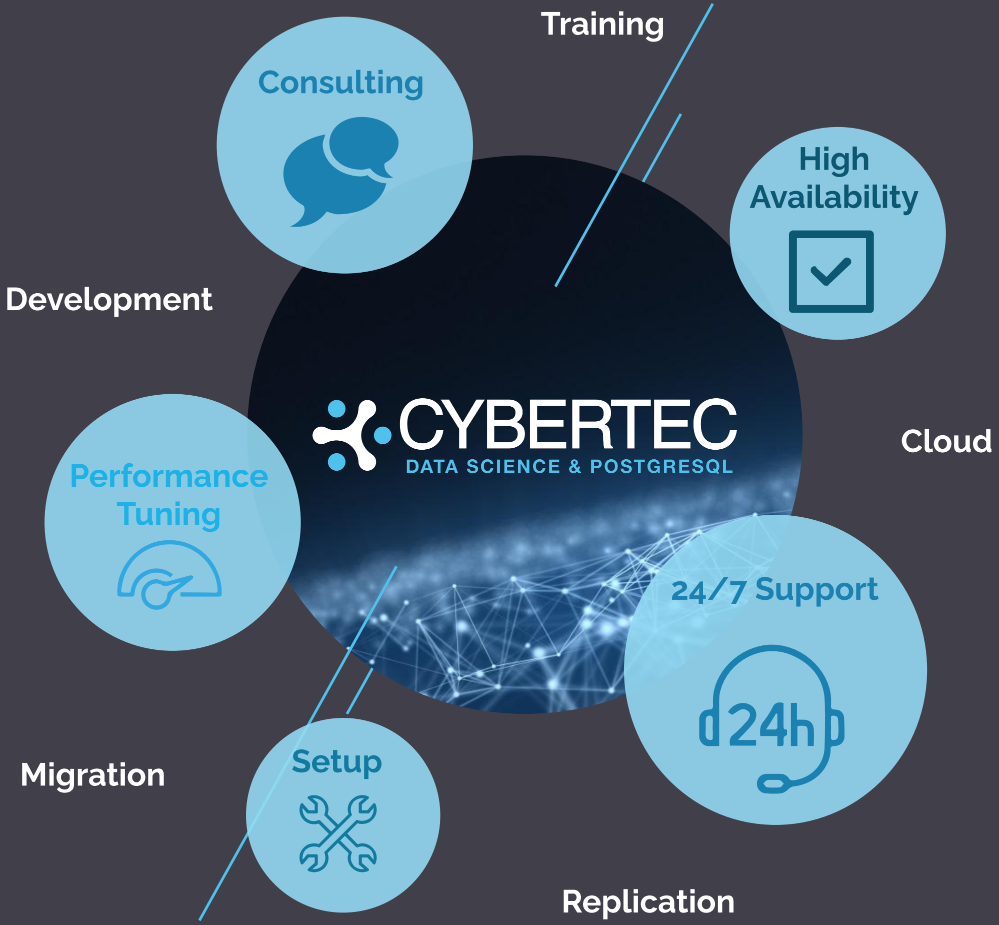

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DATA SCIENCE

- Artificial Intelligence
- Machine Learning
- Big Data
- Business Intelligence
- Data Mining
- etc.

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ADVANTAGES of PostgreSQL

MOST ADVANCED OPEN SOURCE DATABASE SYSTEM

25 YEARS OF DEVELOPMENT

NO LICENSE COSTS

EXTENSIVE FUNCTIONALITY

LOW SUPPORT COSTS

RELIABILITY

SCALABILITY

Today’s agenda

- Intro to Go
- IDEs and tools
- Drivers
- Useful extensions
- Testing

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Intro to the Go

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- ✓ NATIVE BINARIES
- ✓ SIMPLICITY
- ✓ FAST COMPILATION
- ✓ STANDARD LIBRARY
- ✓ CONCURRENCY
- ✓ EASY TO LEARN
- ✓ COMPREHENSIVE TOOLS

WHY
Go

Go is an open source programming language that makes it easy to build simple, reliable, and efficient software. Ii was built to resemble a simplified version of the C programming language. It compiles at the machine level. Go was created at Google in 2007 by Robert Griesemer, Rob Pike, and Ken Thompson.

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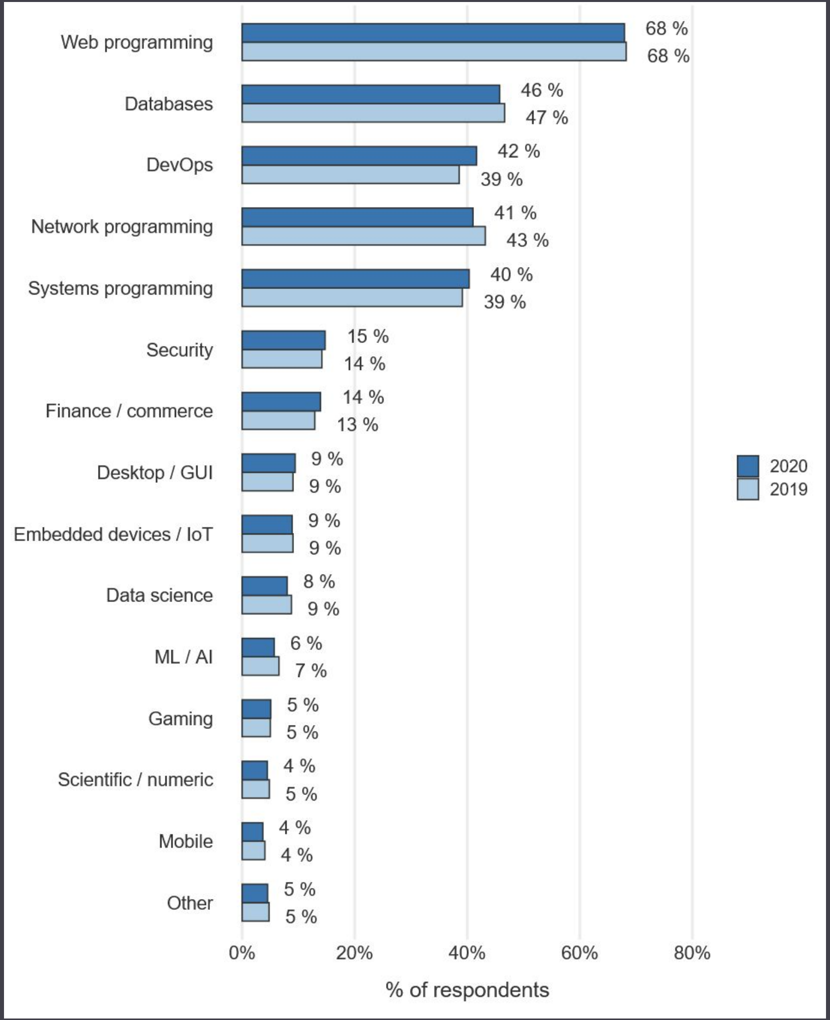
I work with Go in the following areas:

“ We also asked about larger areas in which respondents work with Go. The most common area by far was web development (68%), but other common areas included databases (46%), DevOps (42%) network programming (41%) and systems programming (40%).

https://go.dev/blog/survey2020-results



Top products written in Go

- **Kubernetes (K8s)** - production-grade container management
- **Moby** - a collaborative project for the container ecosystem
- **Hugo** - the world’s fastest framework for building websites
- **Grafana** - observability and data visualization platform
- **Gogs** - painless self-hosted Git service
- **Etcd** - distributed reliable key-value store
- **Caddy** - fast, multi-platform web server with automatic HTTPS

Top products written in Go
PostgreSQL-related

- **pgweb** - cross-platform client for PostgreSQL databases
- **stolon** - a cloud native PostgreSQL manager
- **postgres operators** by Zalando and by Crunchy
- **wal-g** - Archival and Restoration for Postgres
- **pgcenter** - top-like admin tool for troubleshooting Postgres
- **pgwatch2** - PostgreSQL metrics monitor/dashboard
- **pg_timetable** - an advanced scheduling for PostgreSQL
- **pg_flame** - a flamegraph generator for EXPLAIN output

Top products written in Go

- Find more on **https://github.com/avelino/awesome-go**

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IDEs and tools

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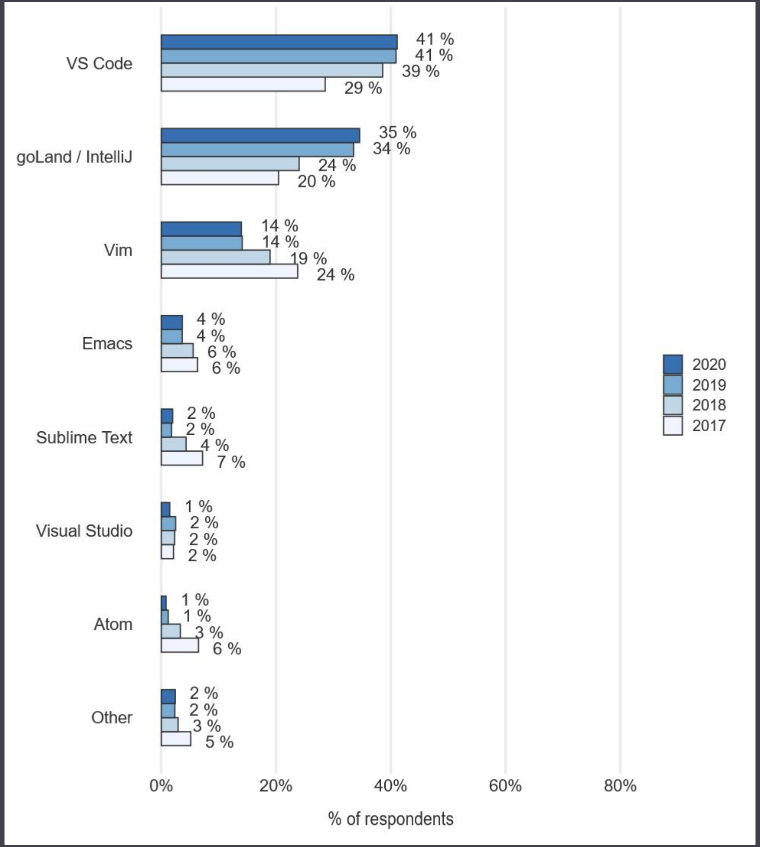
The most popular editors

- **Visual Studio Code** by Microsoft
- **GoLand** by JetBrains
- **Vim & Neovim**
- **Emacs**
- **Sublime Text**
- other

https://go.dev/blog/survey2020-results



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My environment

- **VSCode** with the official vscode-go plugin
- **rakyll/gotest** - `go test` but with colors
- **golangci-lint** - fast linters Runner for Go
- **Tabnine** - the AI code completion tool
- **GoReleaser** - deliver Go binaries as fast and easily as possible
- **PostgreSQL** - most advanced object-relational database
- **gitpod.io** - container-based ready-to-code developer environments

GitHub Integration

- **Dependabot** - maintains repository's dependencies automatically
- **CodeQL** - action runs analysis engine to find security vulnerabilities
- **Build & Test** - action runs on each pull request or manually
- **Release** - action runs on new tag, publishing release
- **Docker** - action runs on every commit, publishing Docker images

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Drivers

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Drivers Availability

- **database/sql** is a set of database access interfaces
  - standard de facto creating database applications
  - needs implementation to work
  - read **http://go-database-sql.org** for more information
- **github.com/lib/pq** - pure Go Postgres driver for database/sql
  - is currently in maintenance mode
- **github.com/jackc/pgx** — PostgreSQL driver and toolkit for Go
  - is the default choice nowadays
  - use this even with **database/sql**

pgx vs database/sql

- Use **jackc/pgx** interface (not **database/sql**) when
  - The application only targets PostgreSQL.
  - No other libraries that require **database/sql** are in use.
- Otherwise use **database/sql** with **jackc/pgx/stdlib**
  - compatibility with non-PostgreSQL databases is required
  - when using other libraries that require **database/sql** such as **sqlx** or **gorm**

pgx features
beyond database/sql

- Support for approximately 70 different PostgreSQL types
- Automatic statement preparation and caching
- Batch queries
- Single-round trip query mode
- Full TLS connection control
- Binary format support for custom types
- COPY protocol support for faster bulk data loads

pgx features
beyond database/sql

- Extendable logging support including built-in support for log15adapter, logrus, zap, and zerolog
- Connection pool with after-connect hook
- Listen / notify
- Conversion of PostgreSQL arrays to Go slice mappings
- Hstore support
- JSON and JSONB support
- Large object support

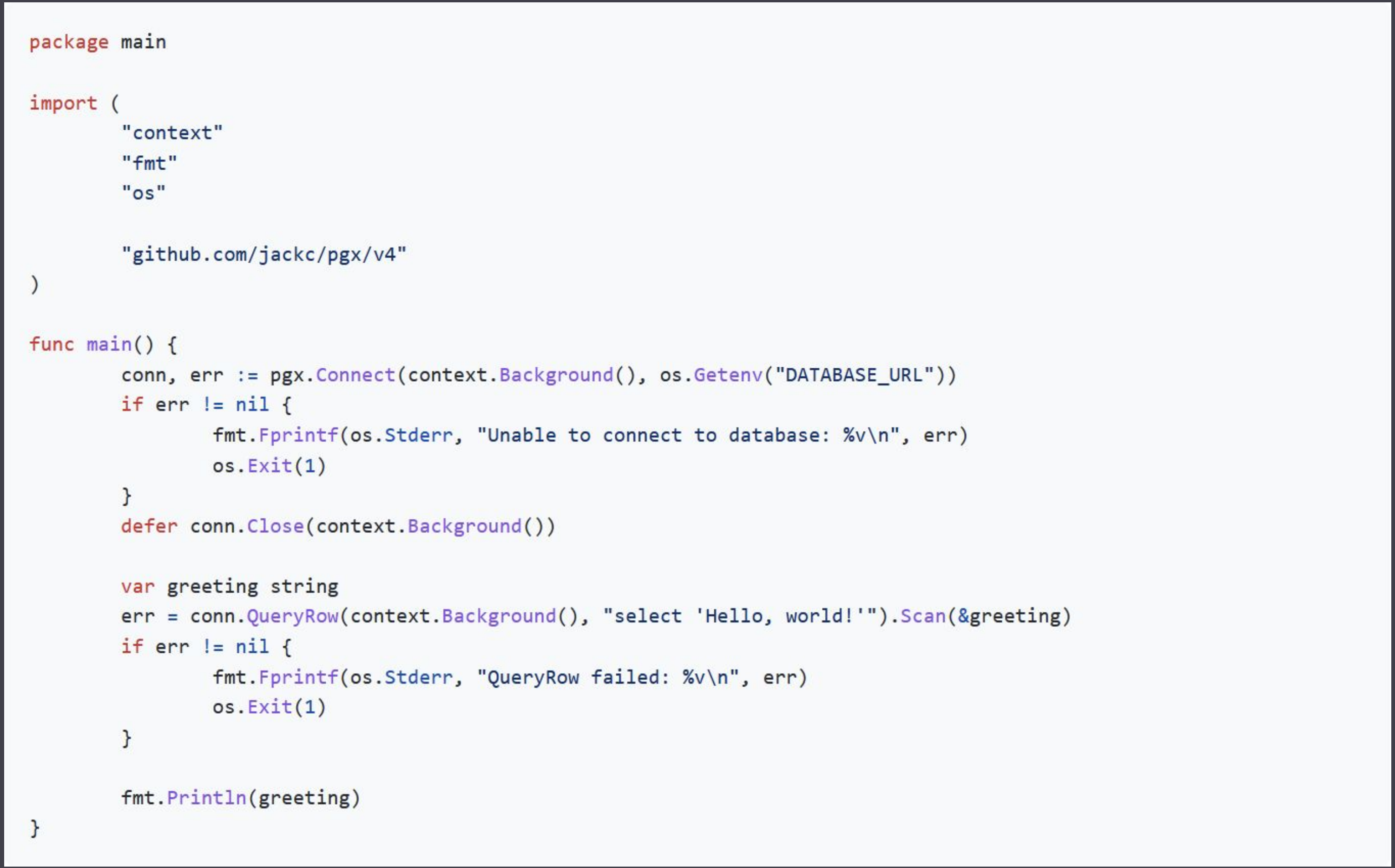
pgx features
beyond database/sql

- NULL mapping to `Null*` struct or pointer to pointer
- Supports database/sql.Scanner and database/sql/driver.Valuer interfaces for custom types
- Notice response handling
- Simulated nested transactions with savepoints

Hello World: database/sql

```go
package main

import (
	"database/sql"
	"fmt"
	"os"

	_ "github.com/jackc/pgx/v4/stdlib"
)

func main() {
	db, err := sql.Open("pgx", os.Getenv("DATABASE_URL"))
	if err != nil {
		fmt.Fprintf(os.Stderr, "Unable to connect to database: %v\n", err)
		os.Exit(1)
	}
	defer db.Close()

	var greeting string
	err = db.QueryRow("select 'Hello, world!'").Scan(&greeting)
	if err != nil {
		fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
		os.Exit(1)
	}

	fmt.Println(greeting)
}
```

Hello World: jackc/pgx



```go
package main

import (
	"context"
	"fmt"
	"os"

	"github.com/jackc/pgx/v4"
)

func main() {
	conn, err := pgx.Connect(context.Background(), os.Getenv("DATABASE_URL"))
	if err != nil {
		fmt.Fprintf(os.Stderr, "Unable to connect to database: %v\n", err)
		os.Exit(1)
	}
	defer conn.Close(context.Background())

	var greeting string
	err = conn.QueryRow(context.Background(), "select 'Hello, world!'").Scan(&greeting)
	if err != nil {
		fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
		os.Exit(1)
	}

	fmt.Println(greeting)
}
```

Hello World: pgxpool

```go
package main

import (
        "context"
        "fmt"
        "os"

        "github.com/jackc/pgx/v4/pgxpool"
)

func main() {
        dbpool, err := pgxpool.Connect(context.Background(), os.Getenv("DATABASE_URL"))
        if err != nil {
                fmt.Fprintf(os.Stderr, "Unable to connect to database: %v\n", err)
                os.Exit(1)
        }
        defer dbpool.Close()

        var greeting string
        err = dbpool.QueryRow(context.Background(), "select 'Hello, world!'").Scan(&greeting)
        if err != nil {
                fmt.Fprintf(os.Stderr, "QueryRow failed: %v\n", err)
                os.Exit(1)
        }

        fmt.Println(greeting)
}
```

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Useful extensions

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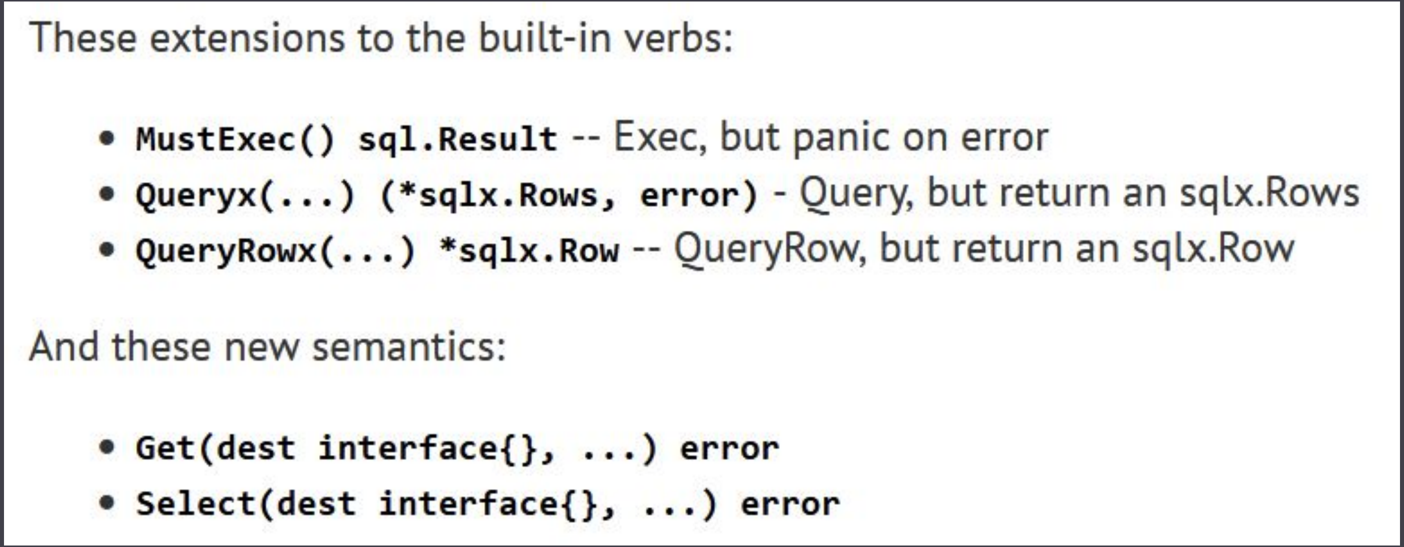
Useful Extensions:
database/sql + jmoiron/sqlx



These extensions to the built-in verbs:

- `MustExec() sql.Result` -- Exec, but panic on error
- `Queryx(...) (*sqlx.Rows, error)` - Query, but return an sqlx.Rows
- `QueryRowx(...) *sqlx.Row` -- QueryRow, but return an sqlx.Row

And these new semantics:

- `Get(dest interface{}, ...) error`
- `Select(dest interface{}, ...) error`

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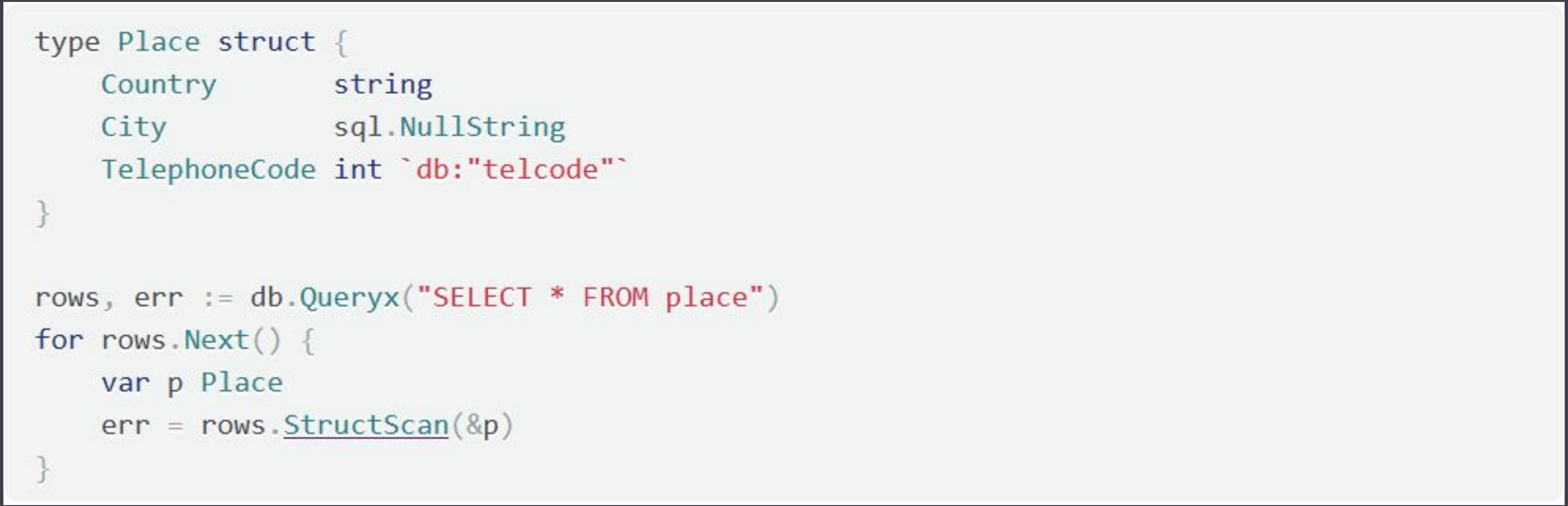
Useful Extensions:
database/sql + jmoiron/sqlx



```
type Place struct {
    Country       string
    City          sql.NullString
    TelephoneCode int `db:"telcode"`
}

rows, err := db.Queryx("SELECT * FROM place")
for rows.Next() {
    var p Place
    err = rows.StructScan(&p)
}
```

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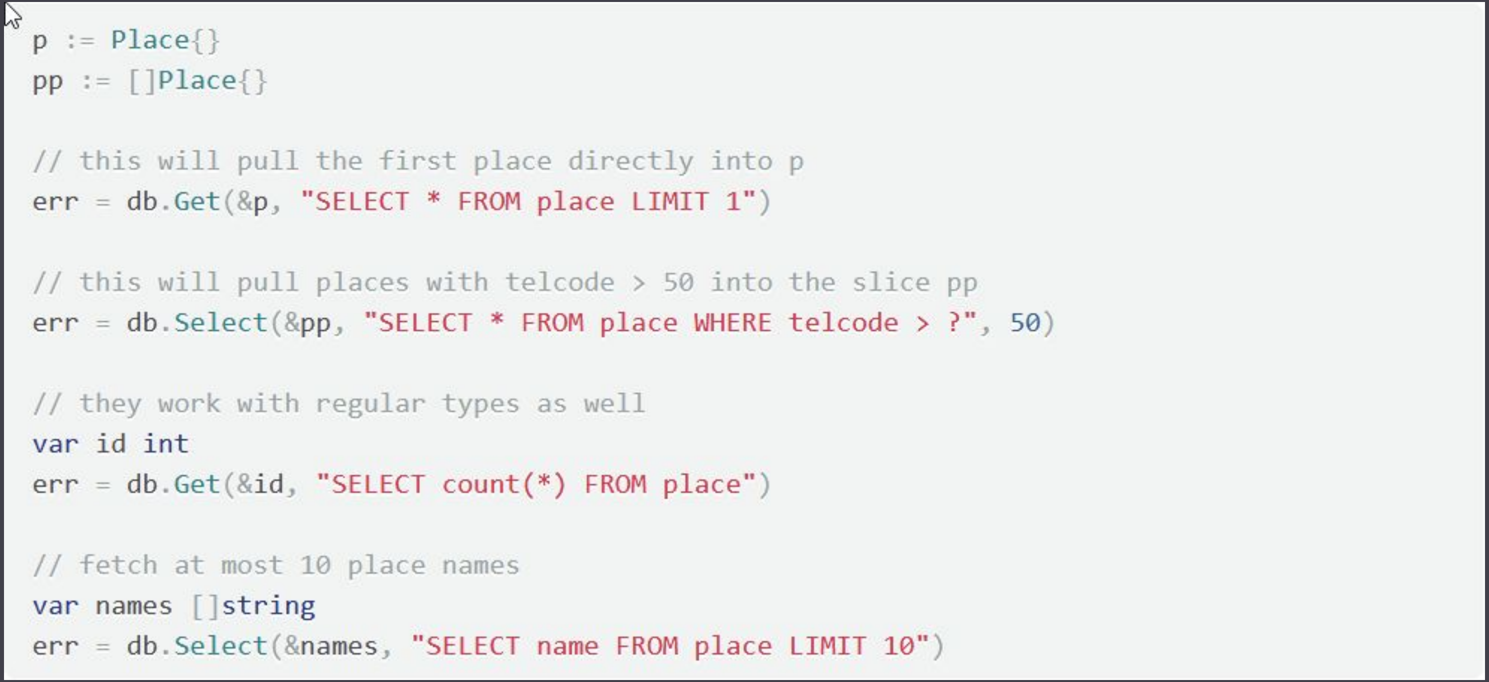
Useful Extensions:
database/sql + jmoiron/sqlx



```go
p := Place{}
pp := []Place{}

// this will pull the first place directly into p
err = db.Get(&p, "SELECT * FROM place LIMIT 1")

// this will pull places with telcode > 50 into the slice pp
err = db.Select(&pp, "SELECT * FROM place WHERE telcode > ?", 50)

// they work with regular types as well
var id int
err = db.Get(&id, "SELECT count(*) FROM place")

// fetch at most 10 place names
var names []string
err = db.Select(&names, "SELECT name FROM place LIMIT 10")
```

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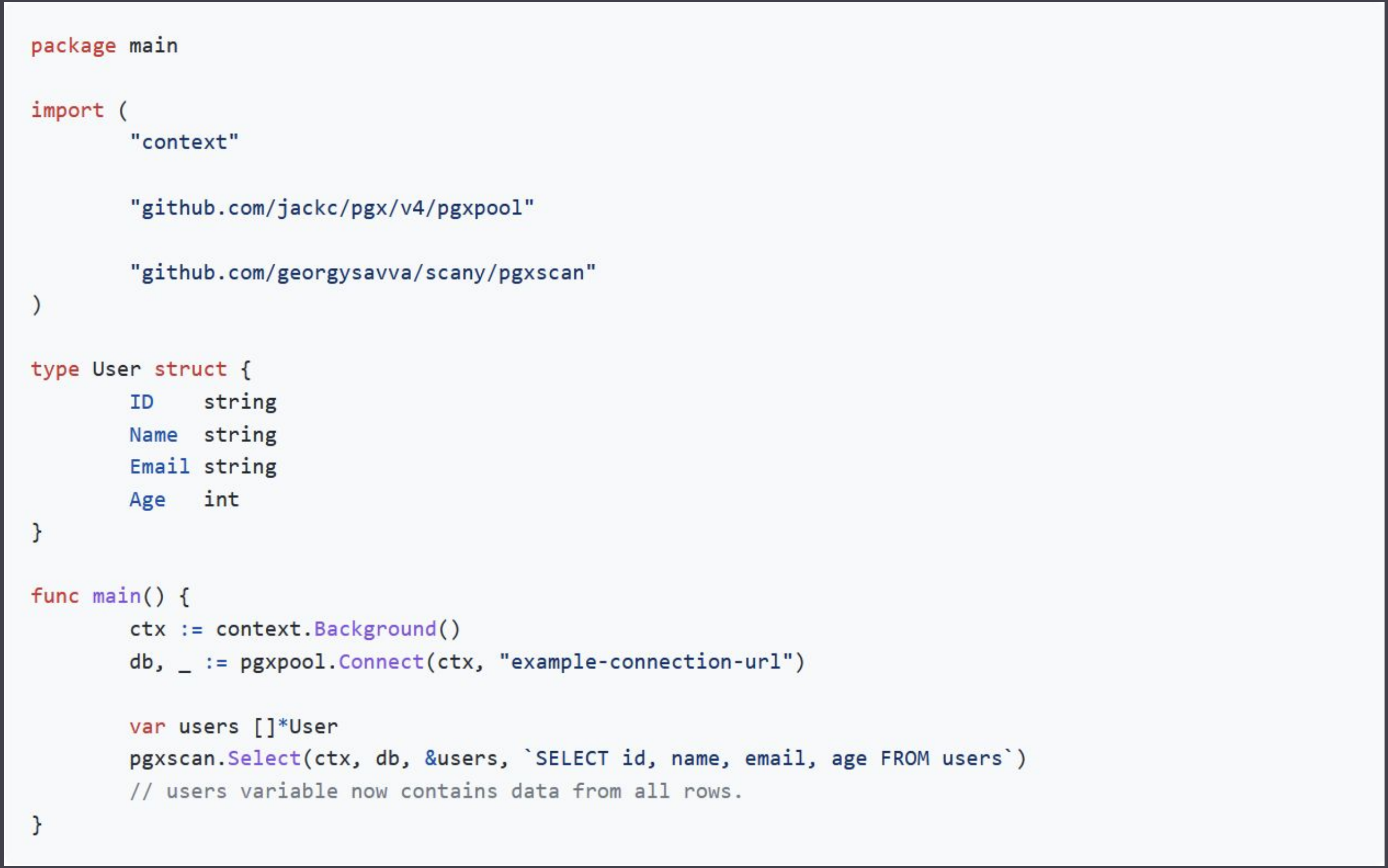
Useful Extensions: scany



```go
package main

import (
        "context"

        "github.com/jackc/pgx/v4/pgxpool"

        "github.com/georgysavva/scany/pgxscan"
)

type User struct {
        ID    string
        Name  string
        Email string
        Age   int
}

func main() {
        ctx := context.Background()
        db, _ := pgxpool.Connect(ctx, "example-connection-url")

        var users []*User
        pgxscan.Select(ctx, db, &users, `SELECT id, name, email, age FROM users`)
        // users variable now contains data from all rows.
}
```

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Testing

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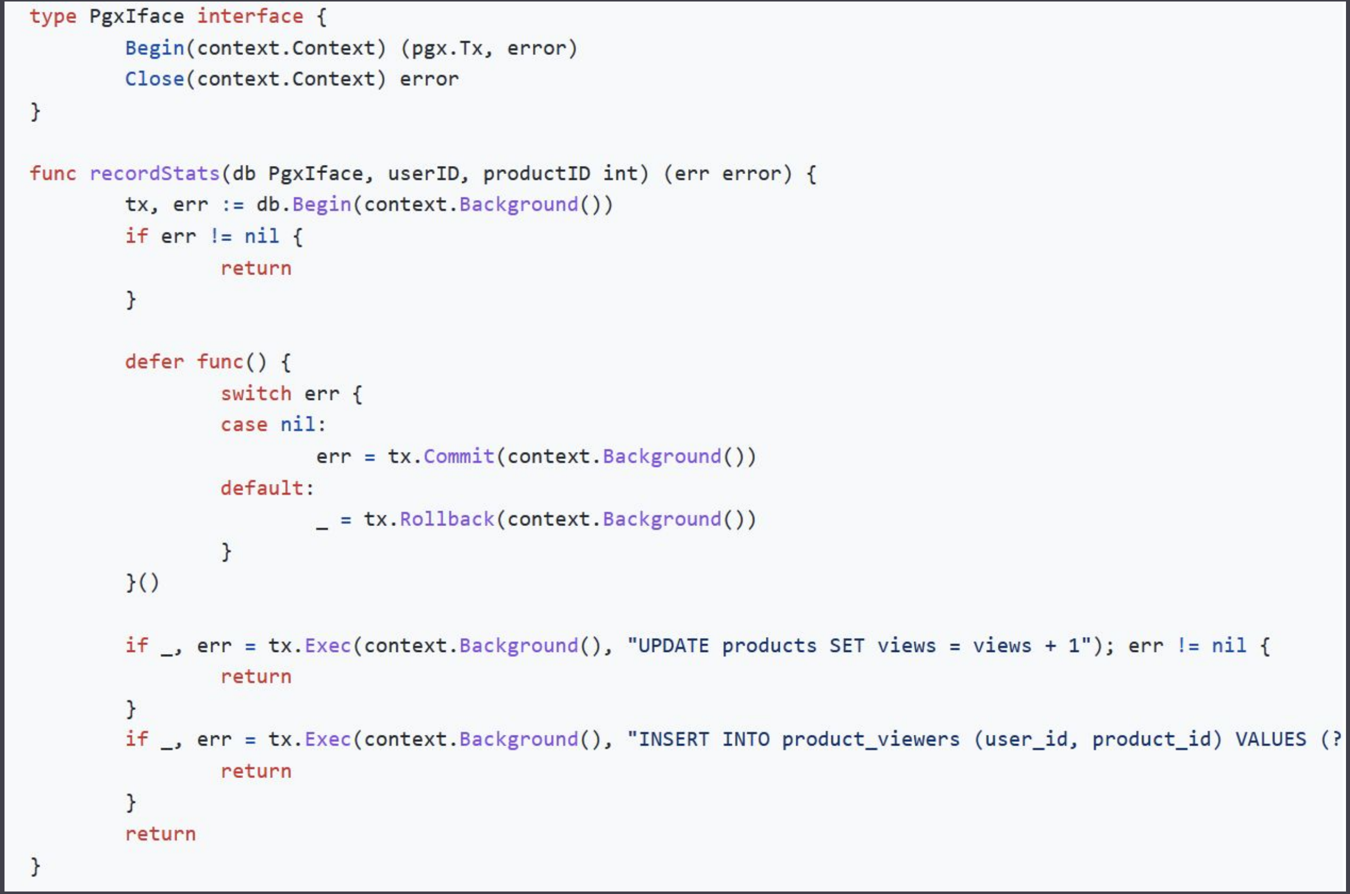
Testing Approaches

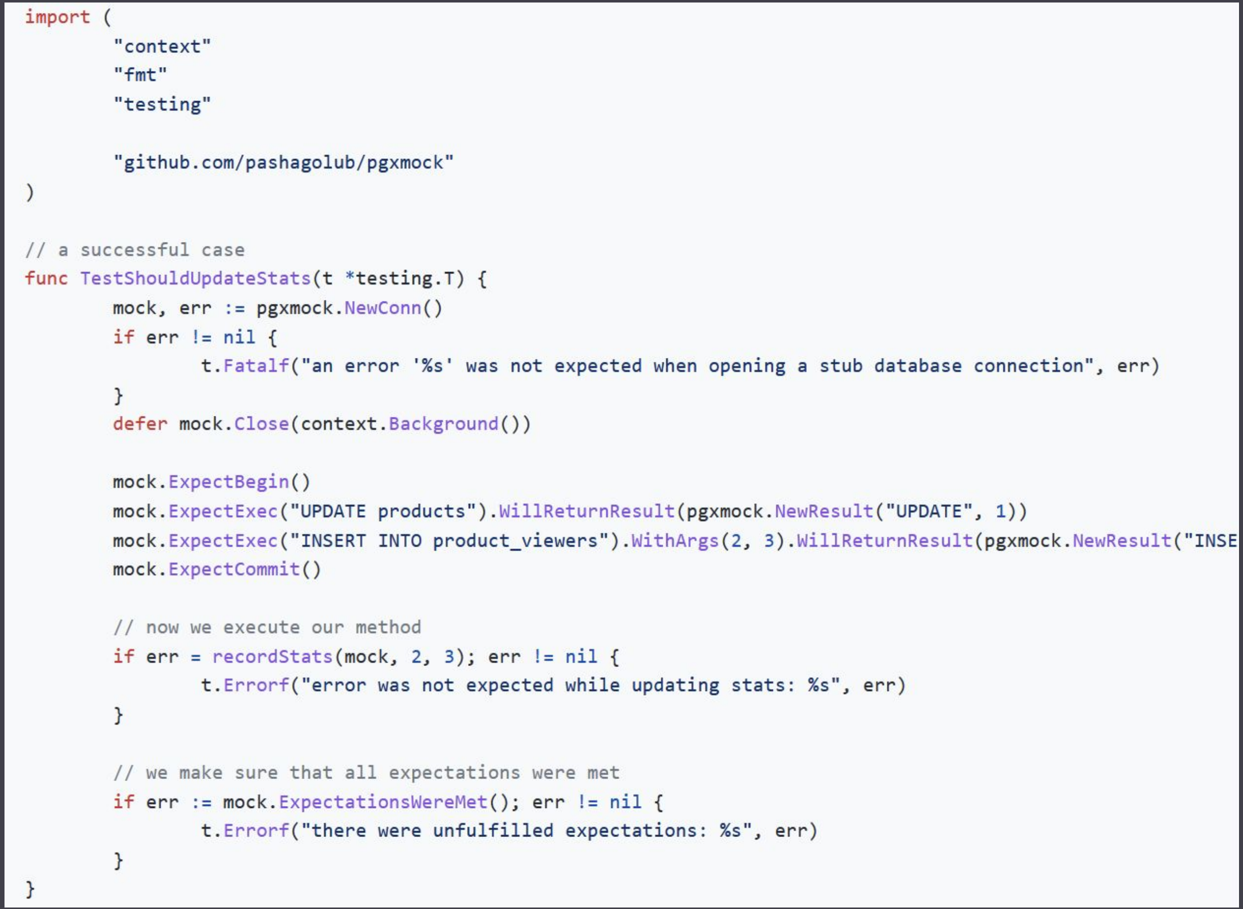
- Real PostgreSQL server
- Mocking libraries
    - **DATA-DOG/go-sqlmock**
    - **pashagolub/pgxmock**
- Mock PostgreSQL wire protocol
    - **jackc/pgmock**
    - **cockroachdb/cockroach-go** Testserver

Mocking Example: pgxmock



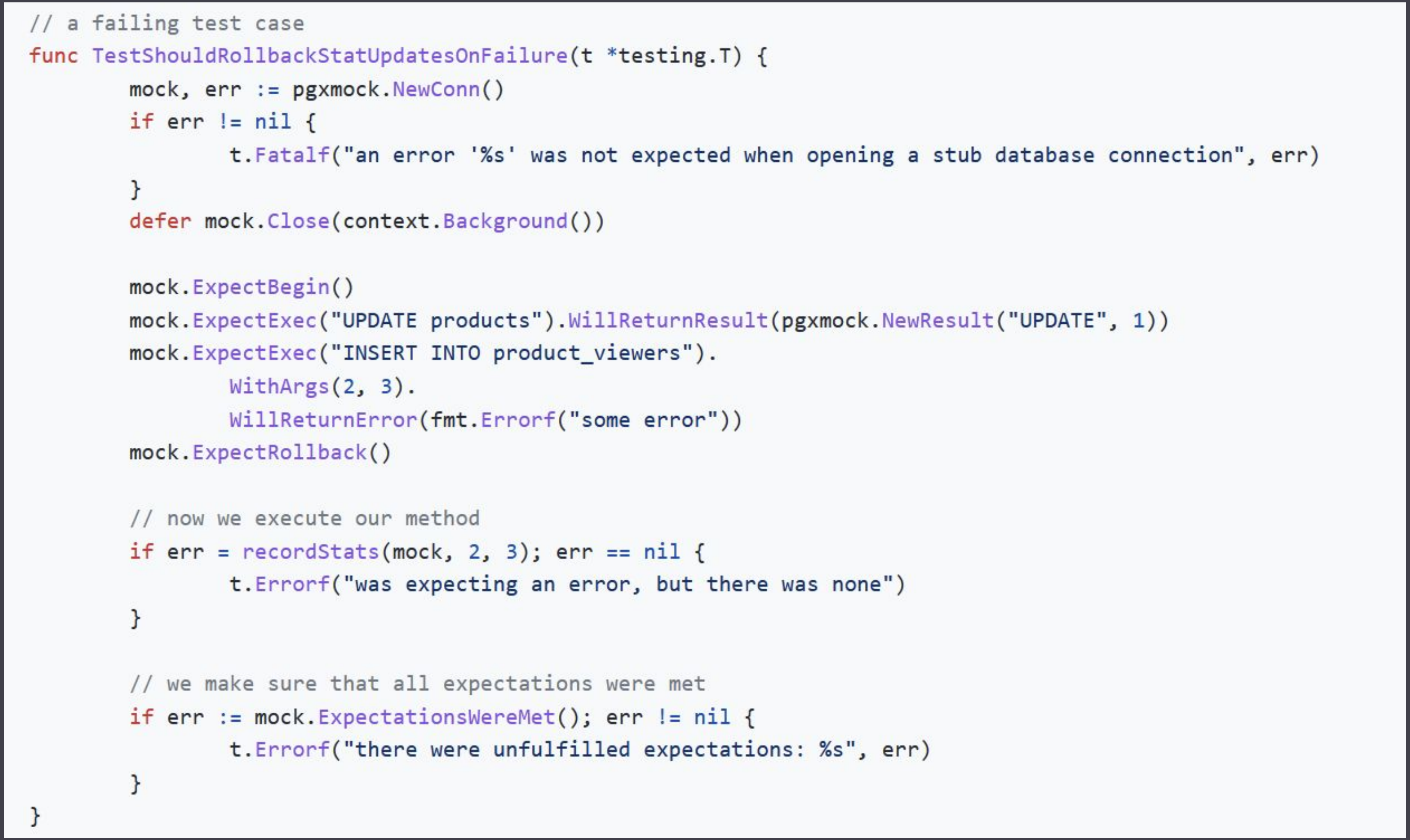
```go
type PgxIface interface {
        Begin(context.Context) (pgx.Tx, error)
        Close(context.Context) error
}

func recordStats(db PgxIface, userID, productID int) (err error) {
        tx, err := db.Begin(context.Background())
        if err != nil {
                return
        }

        defer func() {
                switch err {
                case nil:
                        err = tx.Commit(context.Background())
                default:
                        _ = tx.Rollback(context.Background())
                }
        }()

        if _, err = tx.Exec(context.Background(), "UPDATE products SET views = views + 1"); err != nil {
                return
        }
        if _, err = tx.Exec(context.Background(), "INSERT INTO product_viewers (user_id, product_id) VALUES (?
                return
        }
        return
}
```

Mocking Example: pgxmock



```go
import (
	"context"
	"fmt"
	"testing"

	"github.com/pashagolub/pgxmock"
)

// a successful case
func TestShouldUpdateStats(t *testing.T) {
	mock, err := pgxmock.NewConn()
	if err != nil {
		t.Fatalf("an error '%s' was not expected when opening a stub database connection", err)
	}
	defer mock.Close(context.Background())

	mock.ExpectBegin()
	mock.ExpectExec("UPDATE products").WillReturnResult(pgxmock.NewResult("UPDATE", 1))
	mock.ExpectExec("INSERT INTO product_viewers").WithArgs(2, 3).WillReturnResult(pgxmock.NewResult("INSE
	mock.ExpectCommit()

	// now we execute our method
	if err = recordStats(mock, 2, 3); err != nil {
		t.Errorf("error was not expected while updating stats: %s", err)
	}

	// we make sure that all expectations were met
	if err := mock.ExpectationsWereMet(); err != nil {
		t.Errorf("there were unfulfilled expectations: %s", err)
	}
}
```

Mocking Example: pgxmock



```go
// a failing test case
func TestShouldRollbackStatUpdatesOnFailure(t *testing.T) {
	mock, err := pgxmock.NewConn()
	if err != nil {
		t.Fatalf("an error '%s' was not expected when opening a stub database connection", err)
	}
	defer mock.Close(context.Background())

	mock.ExpectBegin()
	mock.ExpectExec("UPDATE products").WillReturnResult(pgxmock.NewResult("UPDATE", 1))
	mock.ExpectExec("INSERT INTO product_viewers").
		WithArgs(2, 3).
		WillReturnError(fmt.Errorf("some error"))
	mock.ExpectRollback()

	// now we execute our method
	if err = recordStats(mock, 2, 3); err == nil {
		t.Errorf("was expecting an error, but there was none")
	}

	// we make sure that all expectations were met
	if err := mock.ExpectationsWereMet(); err != nil {
		t.Errorf("there were unfulfilled expectations: %s", err)
	}
}
```

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Takeaways

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Takeaways

- Go language is popular, fast, easy and well scaled
- Go is the #1 most in-demand coding language (by Hired)
- 45% of developers use Go to work with databases (go.dev survey)
- You can use your preferred editor or use special IDEs to work
- Kubernetes operators (including Postgres ones) are written in Go
- Go is flexible when working with Postgres: use **sql** or **pgx** interfaces
- Go has powerful programming tools and GitHub/GitLab integration
- Go is backwards compatible. The APIs may grow but not in a way that breaks existing Go 1 code.

Improvement ideas?
User input very much appreciated!

github.com/cybertec-postgresql

github.com/pashagolub

Thanks

Don't be a stranger:

https://www.cybertec-postgresql.com/en/blog/

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QUESTIONS

Senior Consultant/Developer

✉ pavlo.golub@cybertec.at

@PavloGolub

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